

PHOTOVOLTAICS ON INDIAN LANDS

The SOLAR WAY



Sandia
National
Laboratories

ACKNOWLEDGEMENTS

The authors express their heartfelt thanks to the many tribes across the United States who use solar electricity to meet their numerous and varied needs, and who generously gave their time and energy in this shared vision. Thanks go also to the U.S. Department of Energy, Office of Power Technologies, for the support that made publication of **The Solar Way** possible, and for the support given in numerous ways to promote the successful use of PV on Indian lands.

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COVER PHOTO

Rock formation, Narbona Pass, Chuska Mountain Range, Navajo Nation, New Mexico. Since childhood, Paul Denetclaw of the Navajo Nation has wondered when the small rock cradled at the top of the red bluff might fall. Now his children watch.

The cover photo was chosen to symbolize what endures: the sun, power from the sun, the earth, and things on it. (Photo courtesy Roger Hill, Sandia National Laboratories)

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The Solar Way is intended to help tribes make informed decisions about photovoltaics and help PV customers make informed decisions about how to use their systems to the fullest benefit for the longest period of time. PV is a form of “distributed energy resource,” a power source close to the end user rather than generated at a central station and transmitted miles across power lines. PV is, therefore, very well suited to play a large role in creating needed electricity on tribal lands.

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THE **F**IRST AMERICANS, **C**ULTURAL TRADITIONS, AND THE **S**OLAR WAY

There are more than 500 tribes of American Indians and Alaskan Natives living in the United States, on and off reservation lands that range in size from only a few city blocks to millions of square miles of rural lands. It would be a mistake to presume that all tribes are the same or that all their needs are the same.

But with all their diversity, they cherish some common values: caring for the earth and the people on it, caring about future generations, and living as sovereign people, for Seven Generations to come. Within the pages of **The Solar Way** we have tried to present the Seven Generations philosophy, and show how photovoltaics is in harmony with that philosophy.

Simply put, PV captures the sun's energy to generate electricity. It can be used anywhere the sun shines to generate electricity cleanly and quietly and independently – no noxious fumes, no obtrusive power lines. Solar electricity is an enabling technology. It enables tribes to install the power they need for preserving traditions, encouraging sovereignty, maintaining independence, creating jobs, choosing lifestyles, and caring for the earth and her people – for Seven Generations to come.



LEARNING THE WAYS

EDUCATION

Reservation populations throughout the United States are on the rise. Some estimates place the natural population growth at three percent annually. With this growth comes the importance of education for the next generation.

Photovoltaics have been instrumental not only in producing power for tribes, but also in providing the power of knowledge. Several tribes have incorporated units about solar power into their elementary education curriculums. Other tribes have seen the value of renewable energy in their college and adult education programs. This is vital, as tribal colleges support important social change for their communities

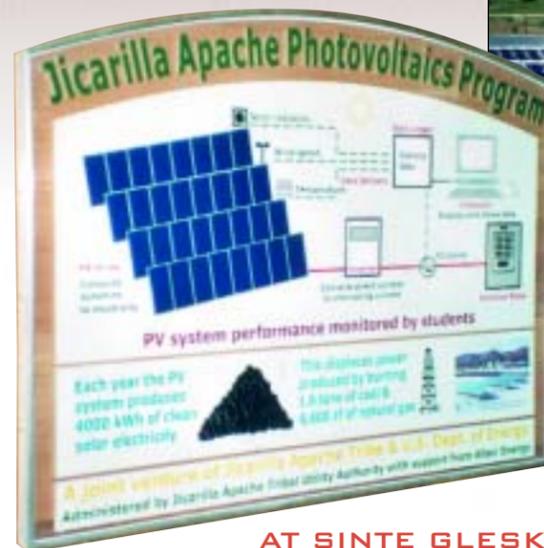
U. S. Department of Energy grants have made some of these PV installations possible. Still others are the result of an impassioned belief among tribes that using the power of the sun is in harmony with their cultural beliefs and in educating the whole child.

CATCHING THE DREAM

▼ Students at the Southwestern Indian Polytechnic Institute (SIPI) in Albuquerque, New Mexico, begin learning about solar energy at an early age, here with a Sun Catcher solar oven. *(Photo courtesy Sandia National Laboratories)*



▲ The Yurok tribe of Northern California uses PV for power at several buildings. Shown here is their Head Start array, which meets the electrical needs of that facility. *(Photo courtesy Sandia National Laboratories)*

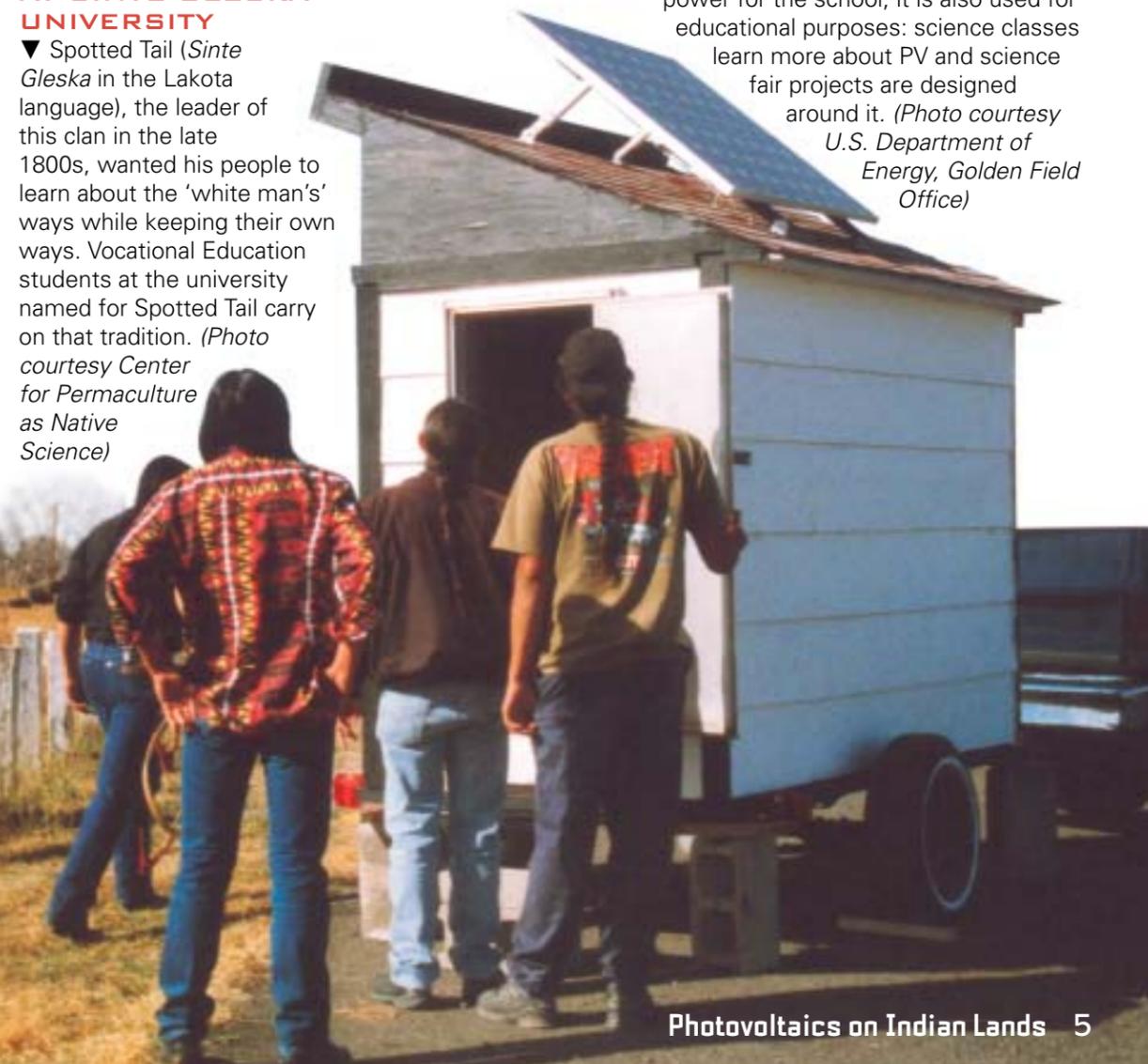


AT SINTE GLESKA UNIVERSITY

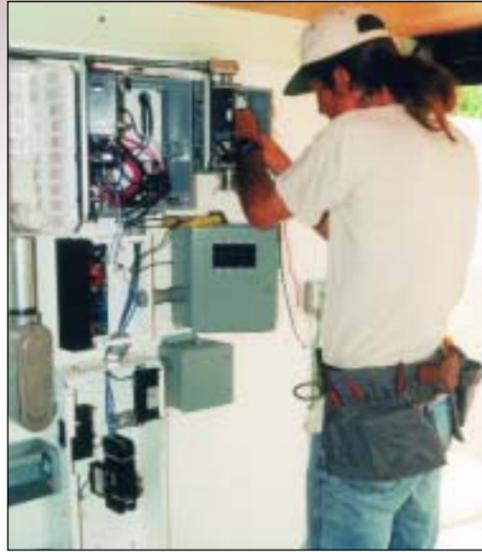
▼ Spotted Tail (*Sinte Gleska* in the Lakota language), the leader of this clan in the late 1800s, wanted his people to learn about the 'white man's' ways while keeping their own ways. Vocational Education students at the university named for Spotted Tail carry on that tradition. *(Photo courtesy Center for Permaculture as Native Science)*



▲ Photovoltaics atop the Jicarilla Apache School at Dulce, New Mexico. Not only does the solar array provide power for the school, it is also used for educational purposes: science classes learn more about PV and science fair projects are designed around it. *(Photo courtesy U.S. Department of Energy, Golden Field Office)*

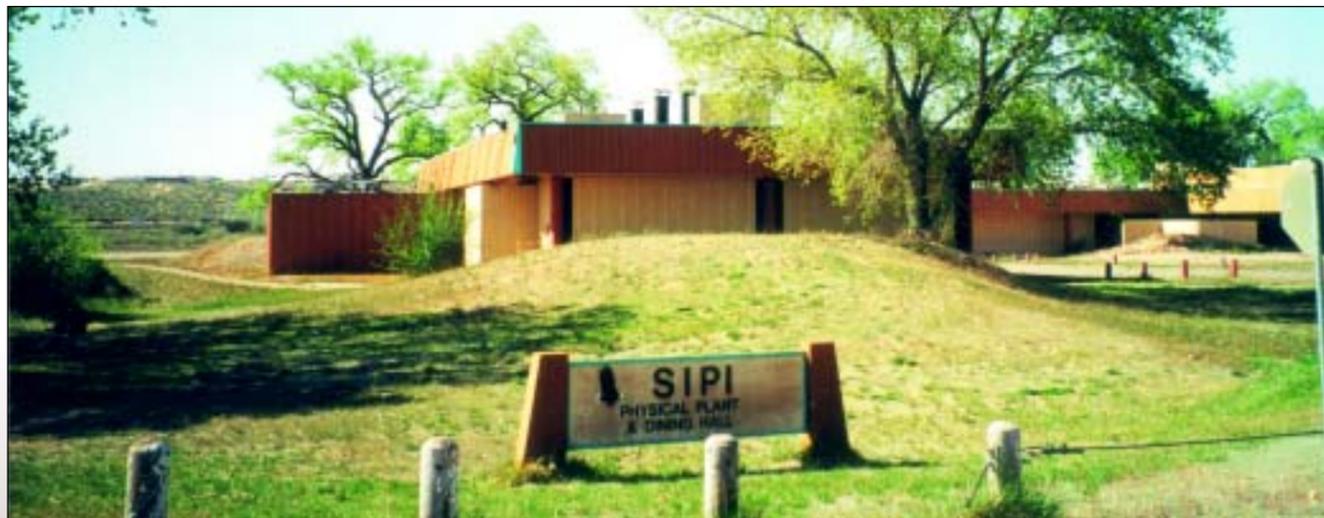


▼ San Juan College, a comprehensive community college in New Mexico, with more than 30 percent Native American student body, embraces a renewable energy curriculum that includes PV – a mature, reliable technology that serves the students well when they return to their homes where conventional energy resources are frequently less than optimal. Depicted are students assembling and working with PV components. (Photos courtesy San Juan College)



**SAN JUAN COLLEGE
ONE-YEAR CERTIFICATE PROGRAM**

PHYS 111	Introduction to Physics	4	RENG 210	Renewable Energy Apps	3	
INST 143	Applied Basic Electronics	6	RENG 220	PV Theory/System Design	4	
INST 141	National Electrical Code I	3	RENG 230	Electromechanical Devices	3	
INST 142	National Electrical Code II	3	RENG 240	PV Installation and the NEC	4	
RENG 171	AC and DC Machines	4				
RENG 190	Principles of Measurement	4				
					Total Credits for Certificate	38



**SOUTHWESTERN INDIAN POLYTECHNIC INSTITUTE, ALBUQUERQUE, NEW MEXICO
THE ADVANCED RENEWABLE ENERGY SYSTEMS AND LAB COURSEWORK AT SIPI**

▲ The SIPI RE course is a part of a certificate program and has been developed to provide an in-depth study of the design, installation, maintenance, and applications of renewable energy systems, with emphasis on photovoltaics (PV) and wind. Power conditioning and storage, safety, troubleshooting, and remote monitoring are covered in detail. The course relies heavily on experiential learning techniques with on-site, portable and fixed renewable energy hardware. Upon completion, students will be familiar with design, installation and maintenance, and can choose a career in the solar industry or continue their education at a 4-year institution.

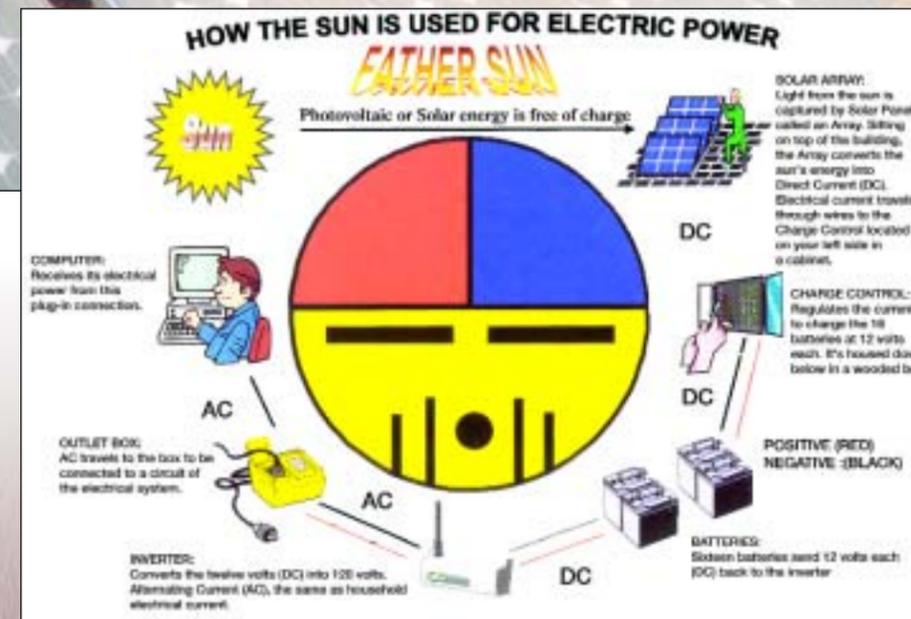
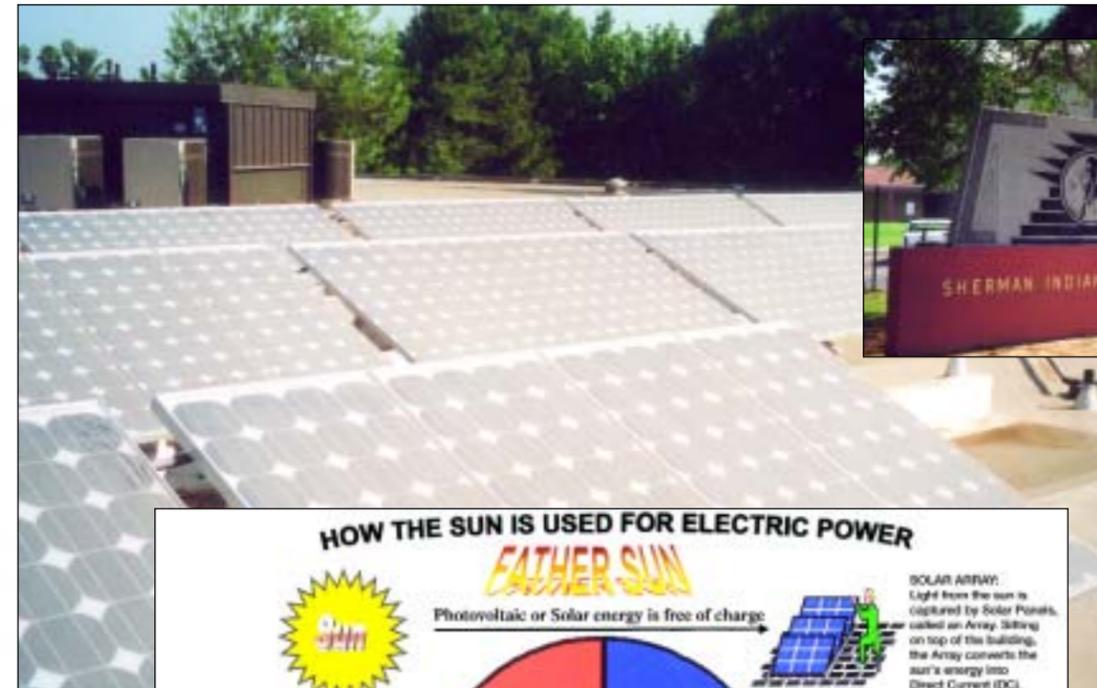


SHERMAN INDIAN SCHOOL

The largest U.S. Native American Boarding School, Riverside, California, is embarking on a major thrust to become more energy efficient. The project will include a PV system. In addition to generating renewable energy, it will provide a teaching tool for the high school's 600 students. (Photos courtesy Sempra Energy Solutions) ▼



◀ The Seba Dalkai Boarding School (K-6) is a Bureau of Indian Affairs-operated reservation school for the Navajo Nation in northeastern Arizona. The photovoltaic system at the school serves as an outdoor classroom and a hands-on laboratory for training about PV. (Photos courtesy Kiss + Cathcart, Architects) ▼



▲ Zuni is considered a traditional pueblo. The "Middle Place of the World" teaches children about Father Sun. (Poster courtesy Zuni Conservation Project)

▲ The Grand Traverse Band of Ottawa and Chippewa (northwestern lower peninsula of Michigan near the Great Lakes) is one of three tribes known as Three Fires. This PV/wind hybrid powers a satellite education office and will provide future power for computers in the education program. (Photo courtesy Grand Traverse Band)

RESERVING THE OLD WAYS

NATURE'S GIFT

The tradition of gift-giving among the Lakota has been cherished for generations. Even with the depressed economic conditions on the Rosebud Reservation, the gift-giving tradition continues. Beekeeping – a way to provide meaningful gifts of honey – is one activity of the Center for Permaculture as Native Science. Success is made possible by photovoltaics, which electrifies fences that keep area ranchers' cattle away from the Lakota

People's honeybees. (Photos courtesy Center for Permaculture as Native Science)



▲ High school students creating fetishes with a PV-powered grinding wheel. (Photo courtesy Zuni Conservation Project)



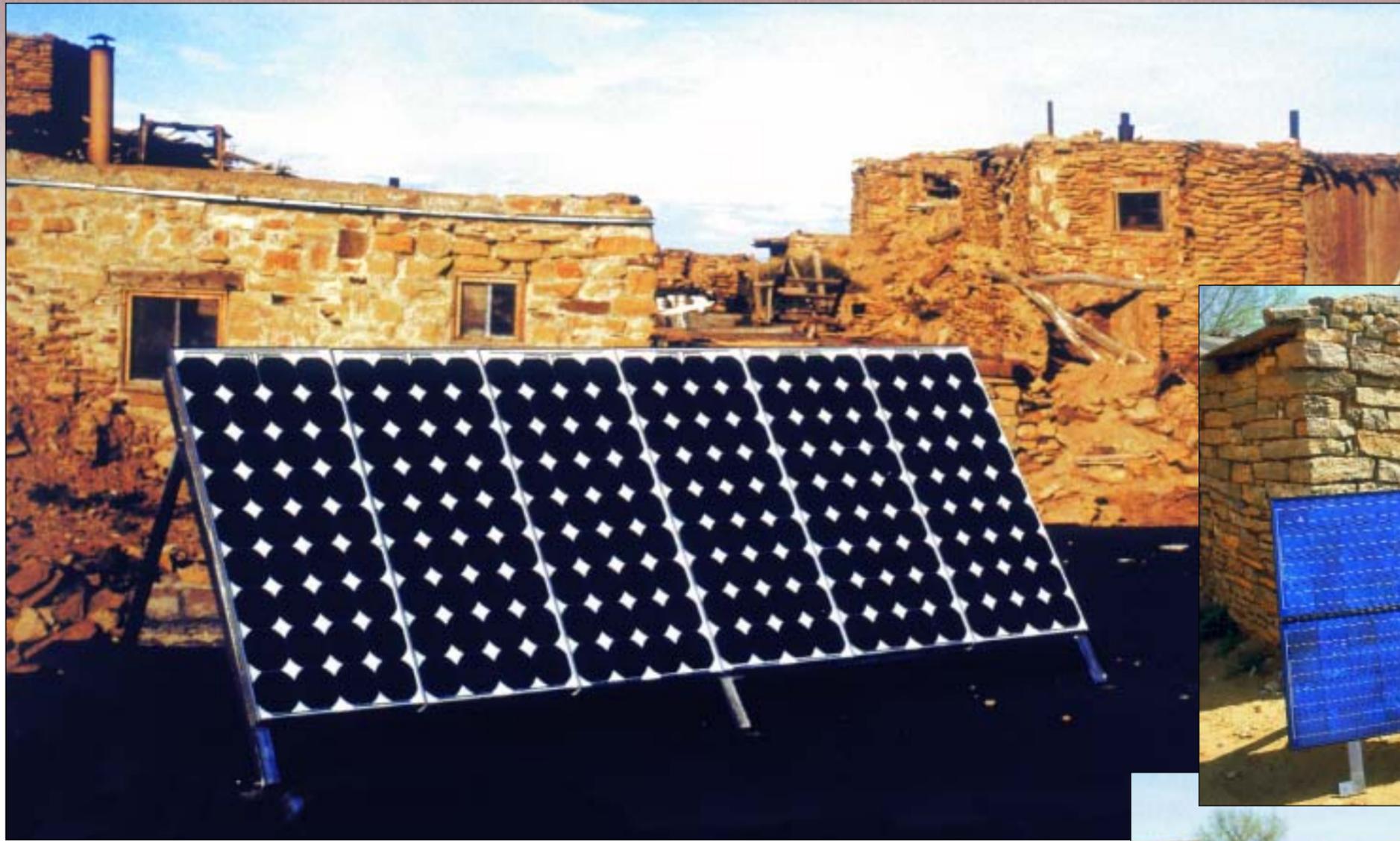
▲ Mabel Ghahate is a beadworker from her home on the Zuni Reservation. Her husband, Silas, herds sheep. Both these elders benefit from PV for lights, where kerosene was previously the only option. (Photo courtesy Sandia National Laboratories and Zuni Conservation Project)



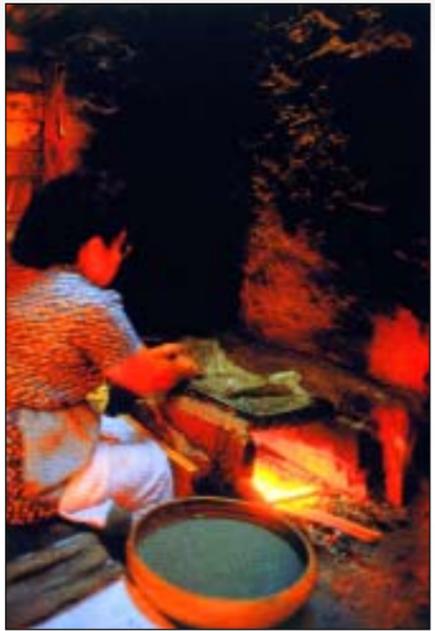
► Drinking water for the Old Pueblo at Santa Ana, New Mexico, is made possible by a PV-powered water pump. In order to keep cultural traditions alive, some villagers at Santa Ana keep two homes – one at the unelectrified Old Pueblo – which is also the site of their festivals and religious ceremonies – and one at their new Pueblo. This solar electric system requires much less maintenance than the windmill it replaced. (Photo courtesy Sandia National Laboratories)

▼ Ceremonies of the Turtle, Wolf, and Bear Clans are held in the Oneida Nation Long House. Tribal elders desire that this traditional log house be kept without utility-provided electricity. Instead, lighting is created with solar power. The building includes two wood heating stoves, and the fans circulate warm air throughout the building. (Photo courtesy Oneida Nation)



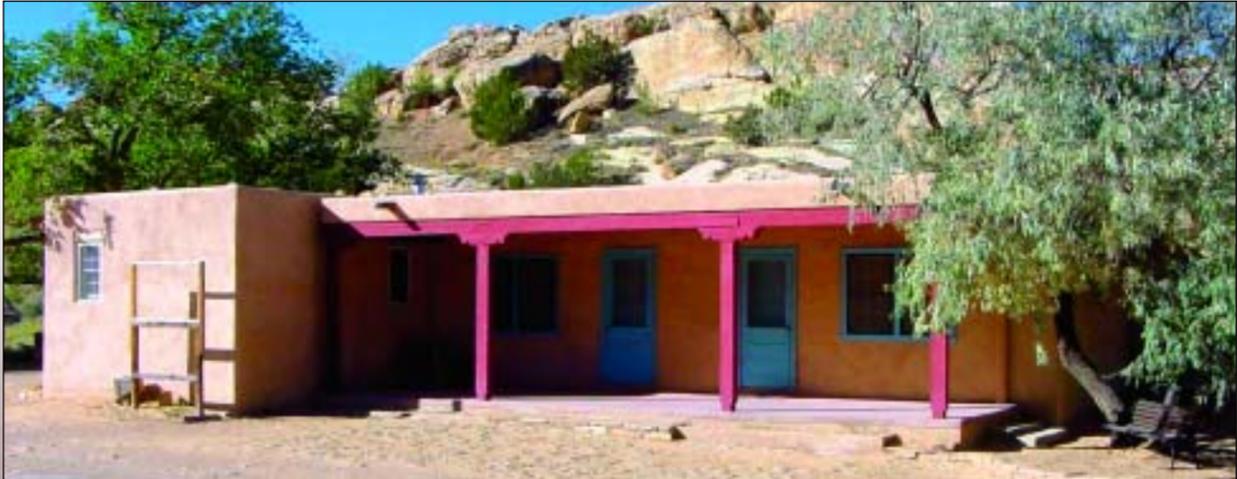


A VILLAGE FOR ALL TIMES
 Old Oraibi, a Hopi village on Second Mesa, Arizona, is the oldest continuously inhabited community in North America. It is also one of a handful of Hopi villages who wish to preserve their autonomy and sovereignty without public power lines, the force fields from which they believe to be disruptive to the atmosphere, ambience, and balance of their lives. Photovoltaics provides modern amenities to villagers at Old Oraibi without compromising Hopi tradition. Yet another tradition made possible by solar electricity is the making of the blue corn piki bread. This bread, reserved for traditional occasions and ceremonies, is prepared in special 'piki houses'. At this one, a portable, light weight array is moved in place only long enough to provide temporary power, and is then removed. (Photos courtesy Hopi Foundation and Sandia National Laboratories)



◀ Inside and outside a Hopi piki bread house.

▼ Two 48-watt PV panels sit unobtrusively atop the roof of a traditional home owned by Christine Pasqual-Sims at Old Acoma, New Mexico. The array provides enough energy for lighting with low-wattage fluorescent bulbs throughout the house – a noticeable difference in cost compared to the family's former use of propane and kerosene lamps. (Photo courtesy Theresa Pasqual-Pruitt)



“You have to keep the sheep – that’s where your strength is.”

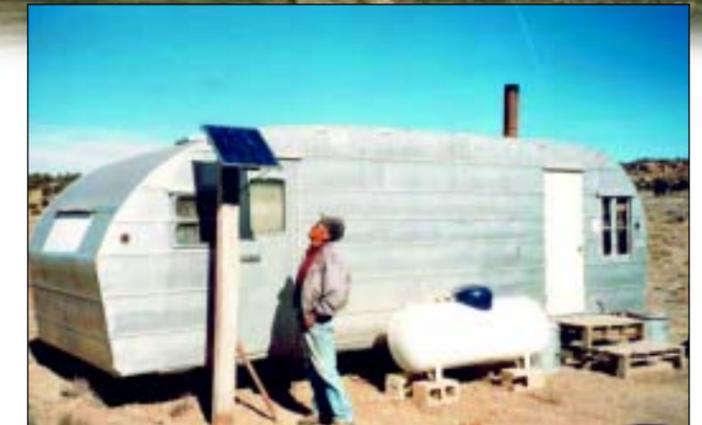
Sharon Begay, Navajo

► The Yazzies are an elderly couple living near the Navajo Nation community of Dilkon. Mr. Yazzie spends long days in the field herding sheep, and Mrs. Yazzie weaves traditional rugs. During the day, her loom is often placed under the PV structure to take advantage of the shade it provides. The couple has long believed in photovoltaics, having had a PV system for more than 15 years. NAPV provides maintenance for the system. (Photo courtesy Kiss + Cathcart, Architects)



KEEPING THE ANCIENT TRADITIONS ALIVE

► Sheep herding is a cultural tradition long-practiced by American Indian tribes, particularly those in the southwestern United States. Up with the sun to take perhaps 150 head to grazing lands – then back to an often isolated camp. PV allows lights and radio to mitigate the loneliness and help attract younger people to keep the herding tradition alive. (Photos courtesy Zuni Conservation Project and Sandia National Laboratories)



▲ Zuni sheep camp. (Photo courtesy Zuni Conservation Project)



► Photovoltaics provides water for raising livestock, a tradition valued by both the Hopi and the Navajo who resettled on the New Lands near Sanders, Arizona. (Photo courtesy The Solar Exchange)



ENDURING SEEDS

SUSTAINABLE AGRICULTURE

Many of the ancient traditions, customs, religion, and arts of the First Americans are observed today as they were centuries ago. Native Americans learned to use the natural resources available to them, notably in their agricultural pursuits, which remain a vital part of their daily lives. From cultivating corn and squash to grazing animals, American Indians preserve their spirituality and provide for their economic needs. In fact, traditional farming and animal husbandry constitute substantial enterprises on many reservations.

Although some Indian lands are located in arid climates, tribes have learned to use the sun to provide water to irrigate their crops and provide sustenance for their livestock.

NATIVE PLANTS

Corn	Beans
Amaranth	Wild Rice
Tomatillo	Chile
Squash	Cilantro
Flax	Flowers
Blue Corn	Potatoes
Quinoa	Sweet Potatoes

Just a few of the native plants nurtured by American Indians

Hundreds of curative drugs have been derived from Native remedies.

◀ Sun drying tomatoes and squash.



THE ROSEBUD LAKOTA EXAMPLE

The basic tenet of the "Permaculture as Native Science" program is that of taking care of Mother Earth, who in turn takes care of the People. The philosophy is rooted in the Lakota *Mitakuye Oyasiñ* – "we are all related." Photovoltaics powers water pumps for agricultural pursuits such as home gardens, tree planting, and animal husbandry. Water for remote pastures is vital, but utility power lines are often far away. (Photos courtesy Center for Permaculture as Native Science)

▶ The Northern Cheyenne Department of Natural Resources, Lame Deer, Montana, uses photovoltaic systems to help manage the quality of their cattle range. (Photos courtesy of Northern Cheyenne Tribe) ▼





▲ The greenhouse at Southwestern Indian Polytechnic Institute plays a key role in its sustainable agriculture pursuits. Native plants will be cultivated for several purposes, among which is a project to detoxify soil and water. (Photo courtesy U.S. Department of Energy, Golden Field Office)

▼ This greenhouse is part of the conservation project at the Zuni Pueblo. The tribe has plans underway to use PV to power circulating fans in the greenhouse, so that they can reinvigorate the growing of native plants. (Photo courtesy Zuni Sustainable Agriculture Program)



“Sustainability is a traditional cultural value.”

Leslie Ramczyk, Lac Courte Oreilles Ojibwa

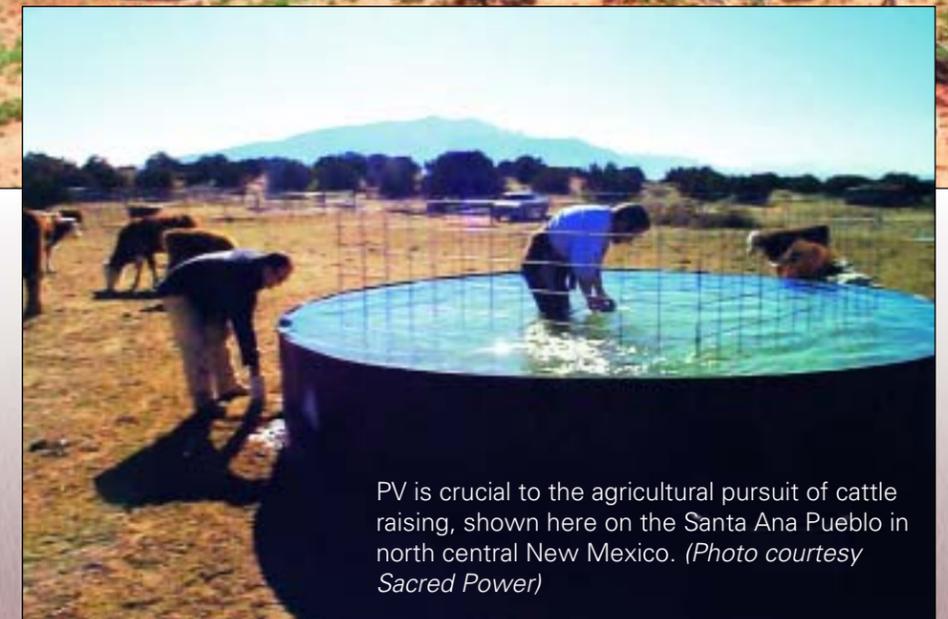


◀ The Lac Courte Oreilles Ojibwa have a PV installation that powers the caretaker's apartment, but it will be relocated to become part of their agricultural program. (Photo courtesy Lac Courte Oreilles Ojibwa)

▶ One of several Ak-Chin Electric Utility Authority's remote terminal units that charge 12 volt dc batteries to monitor the water level in the canal. Access to the canal means the tribe's goal of self-sufficiency is achievable. (Photo courtesy L. S. Gold & Associates, Utility Consultants)



▲ The Zuni Reservation uses several portable solar water pumping systems. When tanks are full, the small systems are moved elsewhere to fill other tanks. The Zuni have thousands of cattle and sheep on their large homelands in western New Mexico. (Photo courtesy Sandia National Laboratories)



PV is crucial to the agricultural pursuit of cattle raising, shown here on the Santa Ana Pueblo in north central New Mexico. (Photo courtesy Sacred Power)

TAKEING CARE OF EARTH MOTHER

NATURE AND THE ENVIRONMENT

Renewable energy projects are considered particularly appropriate on Indian Lands because they are generally environmentally benign and harmonize well with nature, consistent with Indian culture.

The Karuk philosophy that “technical knowledge in itself is insufficient to interpret the... complexity of natural systems,” is a philosophy that appeals to many tribes. Each seeks to bring their cultural processes into agreement with nature, and several have successfully used technology to create this harmony.

► Indian Pueblo Cultural Center Solar Carport, believed to be the largest PV array on Indian lands in the United States. (Photo courtesy Sandia National Laboratories)



▼ Lac Courte Oreilles Ojibwa Community College uses PV to assist in sampling for air pollutants. (Photos courtesy Lac Courte Oreilles Ojibwa Community College)



“MINING THE SKY”

The All Indian Pueblo Council, a consortium of the 19 pueblos of New Mexico, chose photovoltaics for a solar carport at the Indian Pueblo Cultural Center in Albuquerque, New Mexico. Citing David Melton of Diversified Systems Manufacturing, a Native American-owned and operated PV company, the installation “mines the sky.” The positive environmental impact of the carport is weighty. The installation:

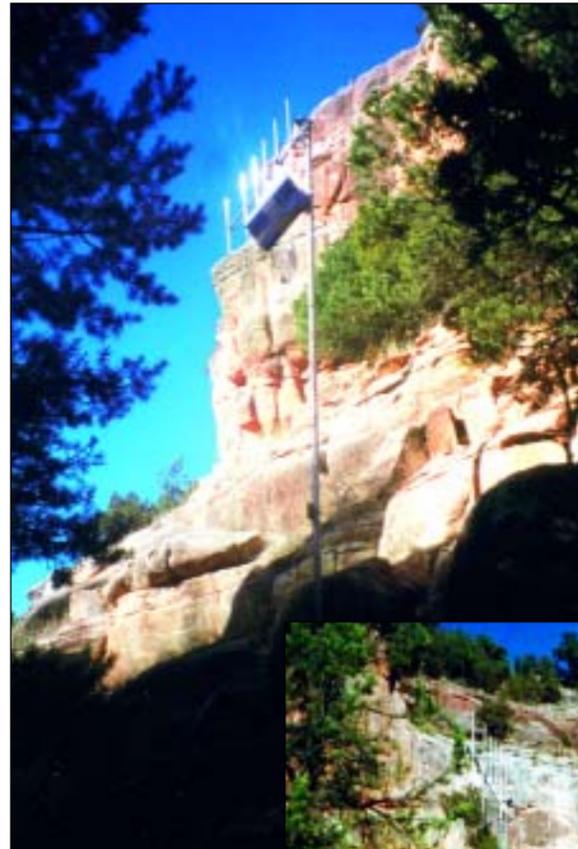
- Avoids mining 43 tons of coal annually
- Saves more than one million gallons of water annually (water that would have been necessary for a coal-fired or nuclear-powered plant)
- Reduces greenhouse gases by avoiding 27.06 tons annually of carbon dioxides, 201.69 pounds of nitrogen oxides, and 347.22 pounds of sulfur dioxides.
- Produces 25 megawatt/hours of clean electricity annually.

◀ A future facility on the campus of the Lac Courte Oreilles Ojibwa Community College, Hayward, Wisconsin, will model integrated renewable energy (including photovoltaics) and solar heating. Other parts of the college’s program will research ways to improve productivity, stability, and sustainability of the global environment. (Photo courtesy Lac Courte Oreilles Ojibwa Community College)

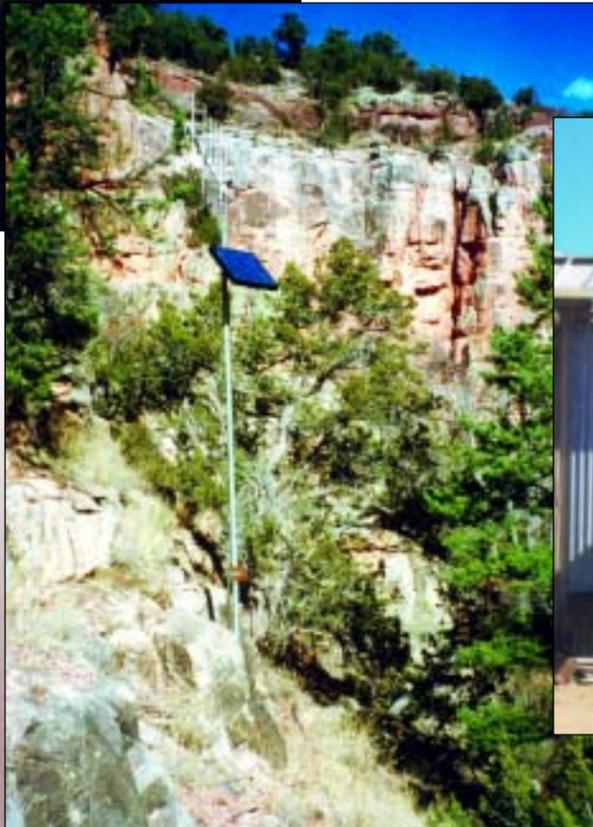


WETLANDS MANAGEMENT

Big Cypress Reservation lies deep in south central Florida, the largest of the five Seminole reservations in the state. Wetlands management and the environmental impacts of runoff associated with development are of paramount interest to the tribe. Using PV, the tribe can collect information about rainfall, water levels, and water samples for parameters such as phosphorous. The tribe also uses the data to monitor natural systems and the environmental impacts of cattle ranching and crop fertilization. *(Photo courtesy Big Cypress Reservation, Linda Billie at the sampling station, G. T. Benock, photographer) ▶*

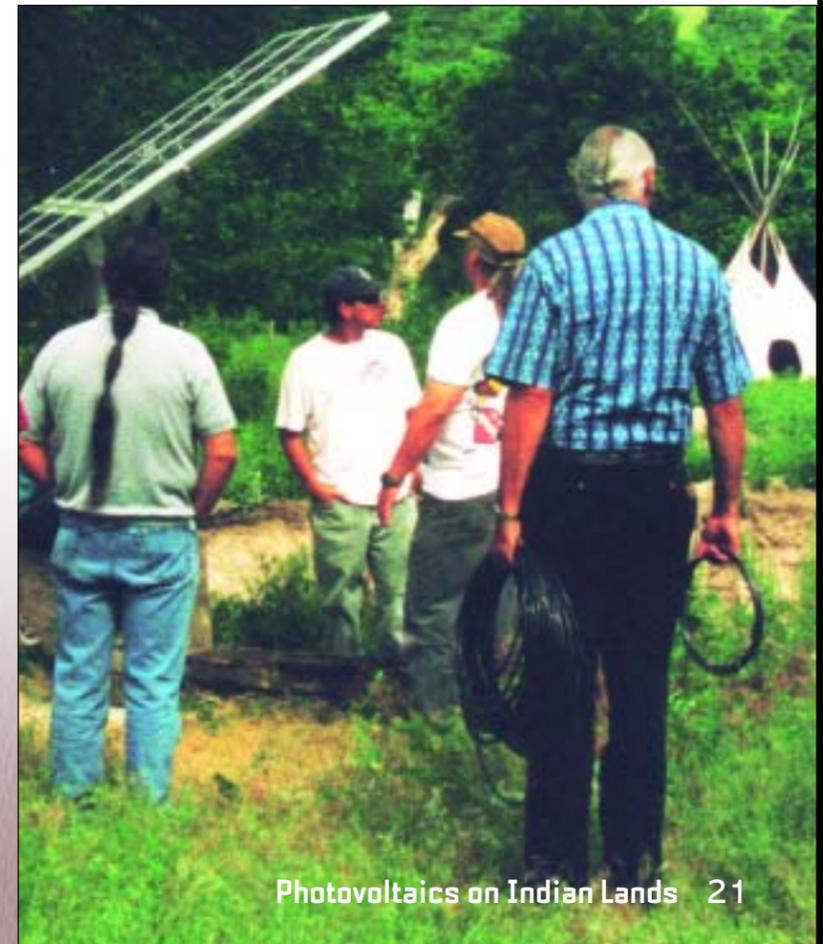


An example of an ecologically-based paradigm for land management may be found on the expanse of the Zuni Reservation lands in western New Mexico. Numerous photovoltaic arrays dot the countryside at strategic locations to monitor the Zuni River watershed that drains off the Continental Divide. Not only does the project ensure the safety of people downstream, but it also helps prevent soil erosion, damage to precious dams, and assists with water conservation. Data on water conditions is collected around the clock and sent to the tribe's hydro project office. *(Photos courtesy Zuni Conservation Project)*



▲ The Zuni Pueblo, located in western New Mexico, uses solar electricity in numerous ways. They are in the process of using PV to pump water to a pond and create a waterfall for the benefit of more than a dozen injured eagles that can no longer live in the wild. Their eco-viary is a sanctuary for sacred bald eagles and golden eagles from all over the United States. The tribe estimates that installing PV to pump and circulate water will save more than 300 gallons weekly – water resources that would otherwise have been wasted. *(Photo courtesy Sandia National Laboratories)*

▼ Members of the Rosebud Lakota tribe know that solar power can play a role in conservation, in their case by substituting for some of the coal-fired electricity brought to the reservation. Individual tribal members design their own small (under 1000 W) systems, choose their components, build and maintain the systems, and then demonstrate to the remainder of the Rosebud Lakota Community how the system has helped take care of Mother Earth. *(Photo courtesy Center for Permaculture as Native Science)*



CARING FOR THE PEOPLE

HEALTH, SAFETY AND SECURITY

Diabetes is more prevalent among American Indians than among any other ethnic group in the United States. In fact, nearly half of all Native Americans over the age of 40 have the disease, which is linked to poor nutrition, lack of proper exercise and other factors. Safe drinking water and refrigeration for medicines and for storing foods safely are other health concerns that can often be mollified by the use of photovoltaics.

Most Americans take access to telephone communications and emergency response systems (police, fire, weather, and other emergencies) for granted. But many American Indians cannot. In an effort to look after the safety and security of their people, some tribes have installed photovoltaic systems. This enabling technology can provide remote power to rural populations wherever they live.



◀ Solar-powered radio telemetry systems send signals via transmitters to provide clean drinking water to 47 tribal homes on the Nez Perce Reservation in Idaho. (Photo courtesy Nez Perce Tribe)



◀ Hoopa Valley Rancheria in California has a swimming pool with filtration and solar heating systems. Because the pool has an air dome, it can be used year-round to encourage physical activity as preventative medicine against health problems. (Photo courtesy Hoopa Valley Rancheria)

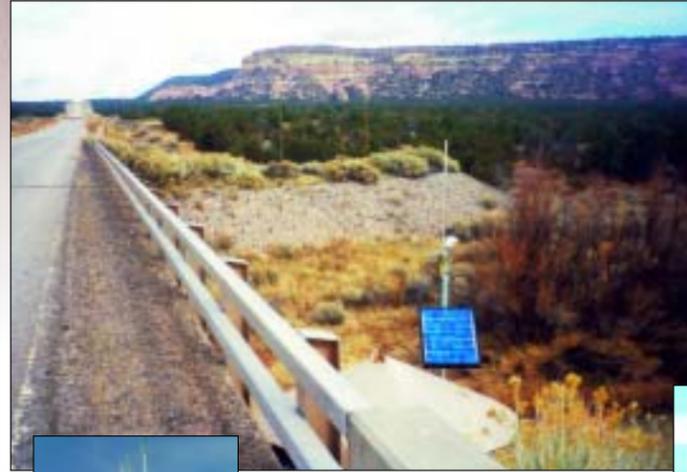
▶ Solar power lights the jogging track at the Pine Hill Health Clinic on the Ramah Navajo Reservation in New Mexico. The lights provide early morning, evening, and even night time use of the track as part of a diabetes prevention program. PV was the power choice even though the grid is nearby. (Photo courtesy Sandia National Laboratories)



A PV telecommunications system extends telephone service from Eureka to Weitchpec on the Yurok Reservation in northern California. Much of the Yurok Reservation is without basic electrical services of any kind. Some believe that a drowning and other fatalities might have been prevented had phone service for summoning medical assistance been available. Background photo shows the raging Klamath River, which runs through Yurok lands. Also depicted are the remote Miner's Creek telecom system and Schoolhouse Peak fire lookout tower that hosts one of the tribe's microwave telecom links. (Photos courtesy Yurok Reservation and Sandia National Laboratories)

“Since losing our traditional diet and sustainable lifestyle, we now experience numerous health problems...”

Lac Courte Oreilles Ojibwa Community College Renewable Energy and Sustainable Development Project



◀ Early warning systems for stream monitoring and dam safety on the Zuni Reservation help protect residents living in harm's way. (Photo courtesy Zuni Conservation Project)

Blue Lake Rancheria, California, uses solar for their air particulate monitoring program and accompanying weather station, which promote air quality and critical emergency response information. Tall Chief A. Comet, Environmental Programs Director, is exploring other applications that can be converted to solar power. (Photo courtesy Blue Lake Rancheria) ▼



▶ PV powers lights along pathways and at intersections at the Acoma-Cañoncito-Laguna Indian Hospital at San Fidel, New Mexico. (Photo courtesy Solar Outdoor Lighting)



◀ The large White Mountain Apache Reservation in eastern Arizona hosts four fire lookout towers, three of which include solar power. These and other PV-powered communications sites also facilitate tribal law enforcement. (Photo courtesy White Mountain Apache Tribe)



▼ The Havasupai Tribe, northern Arizona Grand Canyon area, has installed several photovoltaic systems. The systems provide electricity to facilities such as the jail and housing for police officers. The Havasupai hope to direct cost savings achieved by using solar toward new community and economic development activities. (Photo courtesy Sandia National Laboratories)



“Garden for Health” is a Rosebud Lakota program to promote exercise in the sun and air, and improved diet and nutrition toward the prevention of diabetes among tribal members. Photovoltaic systems pump water for homeowners participating in the home gardening program. (Photo courtesy Center for Permaculture as Native Science)



The Gwich'in Indians (Alaska) of Arctic Village and Venetie relied on noisy, polluting diesel generators, fueled at a high cost, until PV systems were installed on their community washeterias. The laundry facilities contribute to the overall cleanliness – and consequent good health – of the Alaska Natives in the two remote villages. (Photos courtesy Earth Energy Systems, Ltd.) ▼

▲ Refrigeration for medicine and food plays a key role in the health of people living in remote rural settings. Depicted here is a new, much more energy efficient refrigerator being prototyped on the vast Navajo Reservation, where as many as 30,000 homes may be unelectrified. (Photo courtesy SOLUS Corporation, Nevada, and New Mexico State University, SWTDI)

▼ This PV system at the home of Mr. and Mrs. Jackson (Dilkon community, Navajo Nation, Arizona) makes possible the first refrigerator they have owned in years. (Photo courtesy U.S. Department of Energy, Golden Field Office)



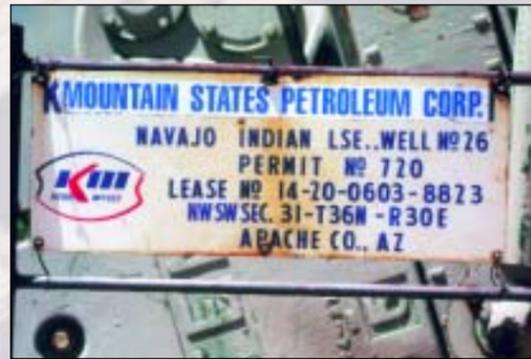
A N ENERGY VISION

ENERGY INDEPENDENCE AND ELECTRICITY SOVEREIGNTY

Indian tribes throughout the United States are stewards of vast natural resources such as oil, gas, coal, and precious metals, yet they often reap very little from these holdings. But perhaps more valuable in the long run are the mighty renewable energy resources American Indian tribes possess – including the perpetual power of the sun.

Several tribes have formed their own utility enterprises, a component of which is sometimes solar energy – photovoltaics. Illustrated on these pages are some of these highly visible and growing activities, destined to play an even greater role in tribal sovereignty in the future.

The Navajo Tribal Utility Authority, in operation for more than 40 years, is the largest Native American utility in the United States. It was created in 1959 as a department of the Resources Division of the Navajo Nation. Randy N. Medicine Bear serves as only the fifth general manager in the history of the NTUA, and Paul Denetclaw leads the engineering department. Headquartered in Fort Defiance, Arizona (with district offices throughout Navajo lands), NTUA provides power options for the tribe — primarily conventional electric power, but a considerable number of residential photovoltaic systems have been installed over the last decade or so. Solar energy accounts for more than a million dollars in assets and saves NTUA millions in line extensions. *(Photos courtesy Southwest Technology Development Institute and Sandia National Laboratories)*



▲ In the spirit of cooperation, students from San Juan College's renewable energy program help NTUA staff troubleshoot a PV system. *(Photo courtesy San Juan College)*



TRIBES THAT	Oneida	Fort Mojave
HAVE	Navajo	Rosebud Sioux
ESTABLISHED	Yakama	Warm Springs
ELECTRIC	Ak-Chin	Jicarilla Apache
UTILITIES	Mescalero	Tohono O'odham
	Cow Creek	Flathead Salish / Kootenai
		Metlakatla Alaska Natives

"All energy on earth derives from the Sun."

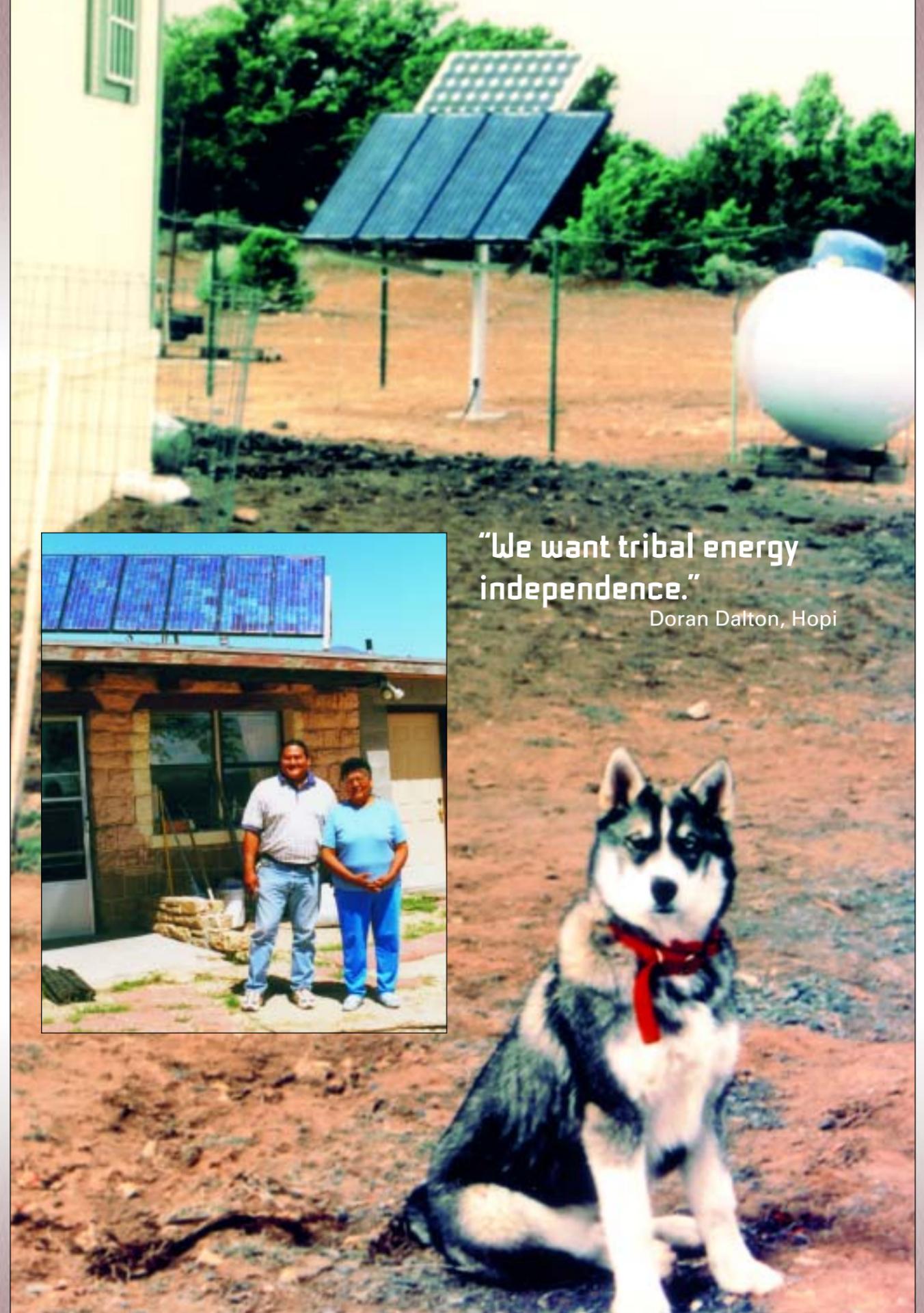
David Lester, Council of Energy Resource Tribes



NativeSUN Solar was created in 1985 within the Hopi Foundation, as one of several projects designed to meet the needs of the Hopi and to encourage self-sufficiency. Through its photovoltaic installations on homes and businesses among the thousands who are living without electricity of any kind, NativeSUN has been an overwhelming success. What began as a non-profit enterprise, is moving forward as a for-profit corporation. According to Doran Dalton, chair of the Hopi Foundation, NativeSUN moves the people toward empowerment and greater self-sufficiency. Among the first to purchase a solar electric system was Dalton's mother (shown with Dalton and her 15-year-old system). Kevin Begay, who now heads NativeSUN Solar, lives off-grid in a home powered by PV, as does Debby Tewa, previous head of the solar enterprise. Also depicted are other examples of solar electrification among the Hopi. *(Photos courtesy Hopi Foundation and Sandia National Laboratories)*

"Self-sufficiency is the greatest Native American concept."

Doran Dalton, Hopi



"We want tribal energy independence."

Doran Dalton, Hopi





▲ More than a decade ago Shan-Diin Solar, an early-day, private PV enterprise of the Navajo Nation, was organized within the Torreon / Star Lake Chapter of New Mexico. More than 50 photovoltaic systems were installed to provide electricity for lights and television. Unfortunately, Shan-Diin Solar ceased operations due to non-technical challenges, but the effort illustrates the great need for electrification that solar energy can provide for rural American Indians. *(Photos courtesy Currin Corporation)*

▶ Three traditional ways of lighting a Zuni home – a kerosene lamp, a propane lantern, and natural sunlight through a window. *(Photo courtesy Sandia National Laboratories)*



THE CERT NATIONAL TRIBAL ENERGY VISION

The Council of Energy Resource Tribes is an organization comprised of 47 federally recognized Indian tribes (and four Canadian First Nations). CERT members all own substantial fossil, hydro, and other energy resources. Publication of the National Tribal Energy Vision 2010 emphasized tribal sovereignty and the opportunity to participate fully in the changes that utility restructuring brings.

◀ Laura Manthe's home on the Oneida Reservation, Wisconsin, is an example of how tribes might approach a variety of energy conservation activities in conjunction with the use of solar electricity on tribal residences. Ms. Manthe took out a \$10,000 loan for the purchase of a 300W PV system, a solar hot water system, and weatherproofing for her home. The 300W PV system with back-up batteries and inverter power a well pump, septic system, sump pump, and one kitchen light. She uses a solar hot water system with a PV pump for hot water needs. Insulation, caulking and weather stripping were upgraded to lower the fuel need. The loan increased her mortgage payment by about \$40 a month, but she estimates she has gained about \$55 a month in energy savings. Following Laura's success, the Oneida Solar Energy Project adopted a policy that all future housing on the reservation that participated in the solar program undergo a similar energy audit. *(Photo courtesy Oneida Nation)*

CHOOSING WELL

QUALITY OF LIFE ON AMERICAN INDIAN LANDS

It should come as no surprise that American Indians want – and need – many of the same things that other Americans want and need. One of these universal desires is to live a life of quality – to live in accordance with one’s own wishes. Solar electricity is playing a part in making these Quality of Life dreams come true.



▲ For more than a decade, Torreon/Star Lake Chapter Navajos (New Mexico) have depended upon photovoltaics to provide lights, radio, and television to their remote homes. *(Photo courtesy Sandia National Laboratories)*



▲ Homes along the river on the largely unelectrified Yurok Reservation in northern California take advantage of PV systems as an alternative energy source. Their only other power option, historically, has been generators with very high fuel costs of up to several hundred dollars each month. *(Photo courtesy Sandia National Laboratories)*



▲ A 960W PV array at the Yavapai Apache Day Care Center (Arizona) provides solar backup at the facility – backup to keep lights, computers, and other equipment running when the primary power supply fails. The system is also used as a teaching tool for the community. *(Photos courtesy Direct Global Power, Inc. and Daystar Consulting)*



◀ The quality of life among the Grand Traverse Band of Ottawa and Chippewa Indians (Michigan) is definitely enhanced by solar systems. Power is provided to vital community centers, as well as to homes. *(Photo courtesy Grand Traverse Band of Ottawa and Chippewa Indians)*



◀ The Sherwood Valley Rancheria is located about 15 miles northwest of Willits, California. While only a handful of homes dot the Rancheria, nearly half are powered with solar energy. All of the Sherwood Valley systems were the choice of individual homeowners, and all meet their quality-of-life needs. *(Photo courtesy Sherwood Valley Rancheria)*



▲ Oneida Solar Project contractors install a 2kW standing seam PV system on the roof of the 7,726 square-foot community center for the Oneida Nation. The electricity provided by photovoltaics allows the tribe to conduct its business activities and celebrate its heritage. The building has heat recovery ventilation, is earth bermed, has energy trusses, light sensors, daylighting and energy detailed to keep the fuel bills manageable. *(Photo courtesy Oneida Nation)*



▲ The Manzanita Band of the Kumeyaay Nation (located in southeastern San Diego County, California) has long recognized their abundant solar and wind resources. A 10 kW wind turbine and a 1.2 kW PV array provide power to a community building on the Manzanita Reservation. The DOE-funded demonstration project is being monitored for three years. As part of the project, Manzanita technicians perform ongoing system maintenance and tribal members receive technical training related to wind and solar energy. *(Photo courtesy Manzanita Band of the Kumeyaay Nation)*



“Indian people represent the highest percentage of Americans not connected to the electric grid. Sometimes this is by choice, but those choosing this traditional way of living should not be denied the benefits that electrification can provide – education or refrigeration, for example. Solar electricity allows the best of both these worlds and is in harmony with Indian people’s culture.”

David Lester, Council of Energy Resource Tribes



LAGUNA MAJORS RANCH

Located nearly a one-hour drive from Interstate Highway 40 in west central New Mexico, the Laguna Pueblo’s Majors Ranch is an example of how photovoltaics (and other renewable energy systems) can provide for an enhanced lifestyle in keeping with the Pueblo’s values. The 20,000-acre Majors Ranch is being revitalized as a haven for Laguna youths, where the old main ranch house will serve as a retreat. Eventually, the Laguna Pueblo hopes to operate the project as a self-contained community. PV, wind, battery storage, and solar thermal will meet the entire electrical and hot water needs of the buildings. *(Photos courtesy Sacred Power Corporation, Diversified Manufacturing Systems, and U.S. Department of Energy Golden Field Office)*





LIME, AN ALASKA NATIVE VILLAGE

▲ Summer or winter, photovoltaics provides amenities that add to the quality of life in Lime, Alaska. For several years the village has been using a 35kW diesel generator, 24 hours a day, 365 days a year. Installation of the large 12kW array permits the village to shut off the noisy diesel during solar peak hours. Lime residents often comment on the sustained periods of silent power generation that PV allows. *(Photos courtesy Northern Power Systems)* ▼



SALISH KOOTENAI COLLEGE PROVIDES PUBLIC TELEVISION

In 1993, television translator K48EG went on-air, providing public television service to the Flathead Indian Reservation and some outlying areas of western Montana. When the local power company wanted more than \$50,000 to extend electricity to enlarge the service area, the college instead chose a solar system that was only slightly over half the total cost of conventional power. In the dead of winter, operations are curtailed to no more than six hours a day, but without this solar-powered facility, public television would not be available in some areas of the Flathead Indian Reservation. KSKC-TV is owned and operated by the Salish Kootenai College, a tribal college. *(Photos courtesy Salish Kootenai College Media)*



TOWARD ECONOMIC INDEPENDENCE

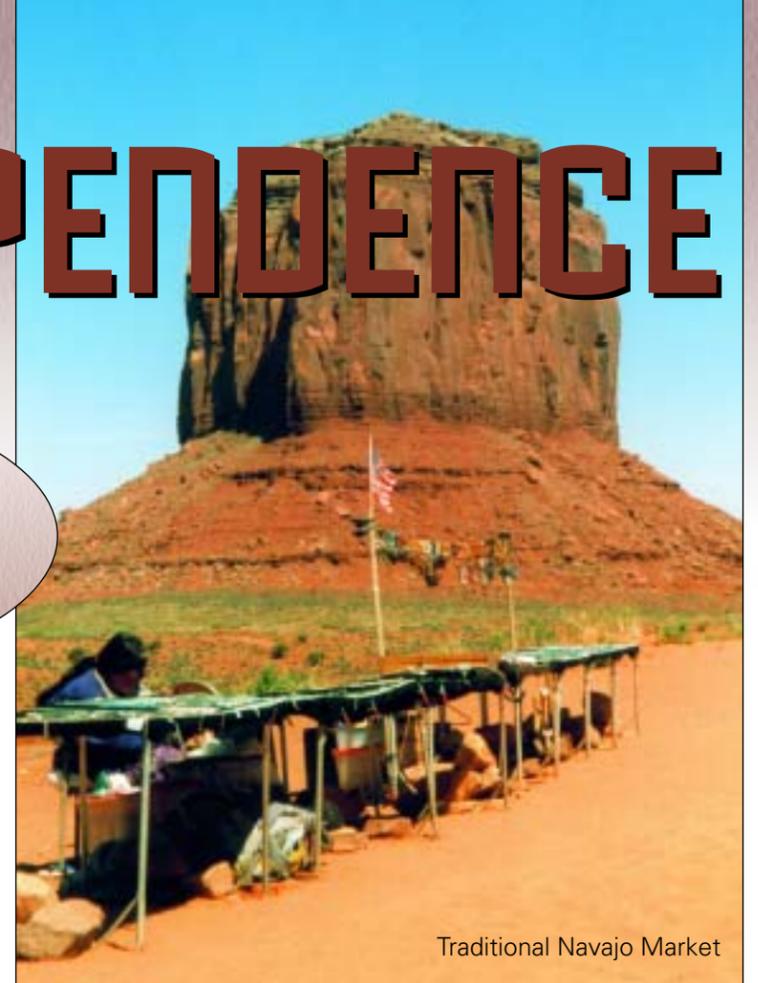
By any measure, Native American communities today lack many of the resources and infrastructure capacity they need to promote viable economic development: gas, phones, roads, educational facilities, and electricity. As the examples here will demonstrate, photovoltaics is playing an ever-increasing role in a variety of economic enterprises.

Sandra Hamana operates Hamana So-o's Arts and Crafts at the village of Old Oraibi, Arizona, on the Hopi Reservation. The artist has adopted photovoltaics for her shop, the electricity from which allows fans, lights, music and the opportunity to do business as she wishes. No electrical lines are allowed at Old Oraibi, so the only other power choice for residents is diesel generators. *(Photos courtesy Sandra Hamana and Sandia National Laboratories)*



Local autonomy, with its emphasis on tribal values, is the foundation for economic independence.

▼ The Bad River Reservation in northwestern Wisconsin is the largest Chippewa reservation in the state. For more than a quarter-century, the tribe's fish hatchery has restocked millions of walleye into the Bad River System. The PV/hybrid wind system powers the activities of the hatchery and produces a significant portion of its electrical consumption during the year. *(Photo courtesy Great Northern Solar)*



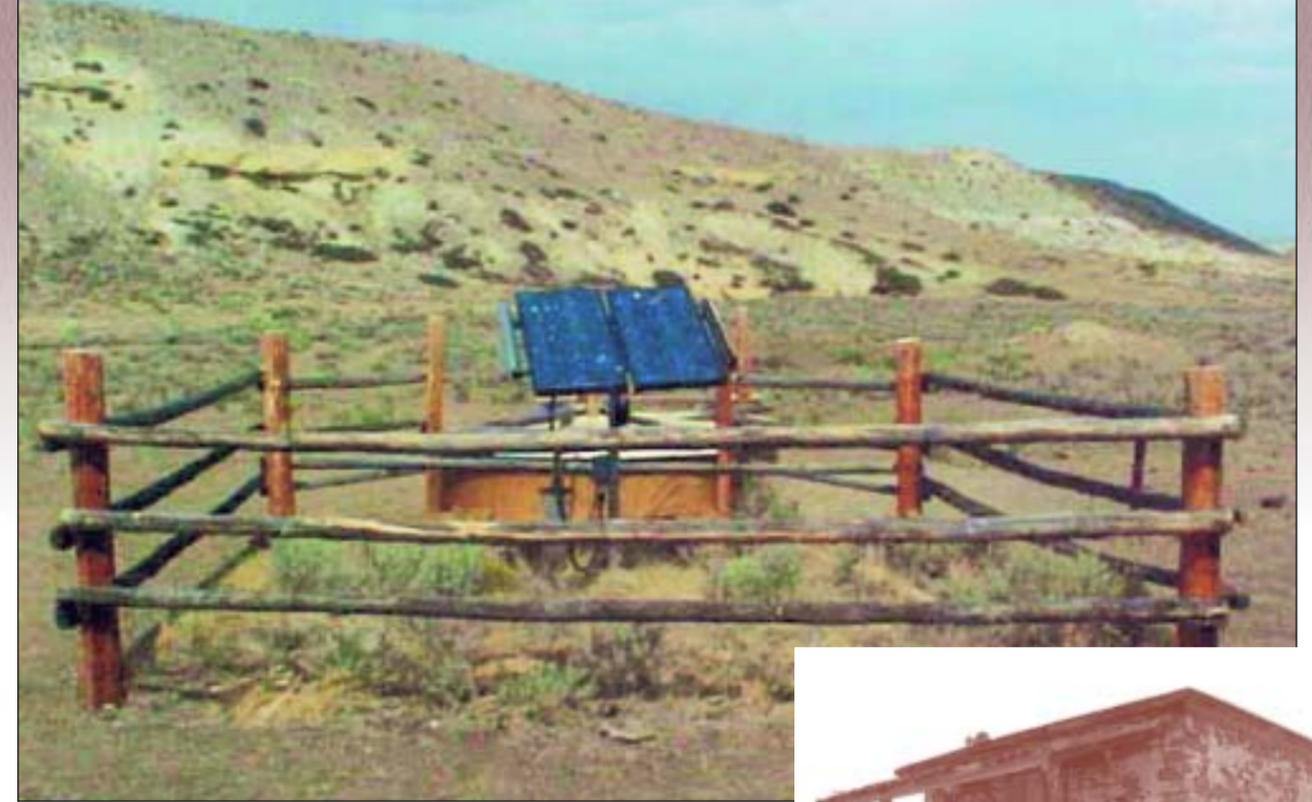
Traditional Navajo Market



The Hualapai Tribe of northern Arizona reaps the economic benefits of a growing tourist facility on the Grand Canyon Rim, which receives an average of 500 visitors daily. This commercial enterprise is operated as the Grand Canyon West Visitors Center. Since the facility lacked water resources, the tribe's creative decision was to pump from their Westwater location via photovoltaics from more than 26 miles away. For other necessary facilities at the site (located more than 20 miles from the electrical grid), solar power was a very attractive alternative. (Photos courtesy *The Solar Exchange and Sandia National Laboratories*)



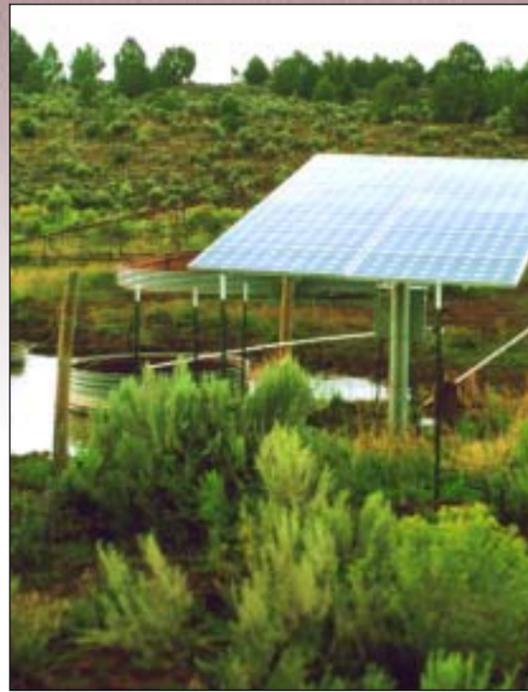
▼ The Havasupai tribe of northern Arizona offers Grand Canyon tours (see page 24 to learn more about their PV installations). (Photo courtesy *Sandia National Laboratories*)



The Wind River Indian Reservation, located in west central Wyoming, is home to more than 3,000 Shoshone and more than 7,000 Arapaho tribal members. The Shoshone and Arapaho live on the same reservation, with trust affairs handled by the Bureau of Indian Affairs Wind River Agency, Ft. Washakie, Wyoming. For more than ten years, photovoltaic systems have pumped water at numerous wells throughout the 1.8 million acres of range and forest lands on the reservation. The rangelands are permitted to more than 100 individual ranchers, so PV helps provide one of the primary means of livelihood for the Shoshone and Arapaho. (The Historic Wind River Agency Blockhouse, right) (Photos courtesy *BIA Wind River Agency*)



▲ The Oneida Nation (Oneida, Wisconsin) has installed PV at several sites, including an elementary school, elder center, land management facility, and day care center, to create electricity for signage lighting. PV will soon play a large role in the tribe's economic development. The Oneida Community Grocery Store will feature a 10kW ground-mounted system, which will provide power to the Oneida Co-operative Grocery Store. The equipment and remodeling will also meet energy guidelines to lower the overall life-cycle maintenance budget and help on the profit margin. (Photos courtesy *Oneida Nation*)



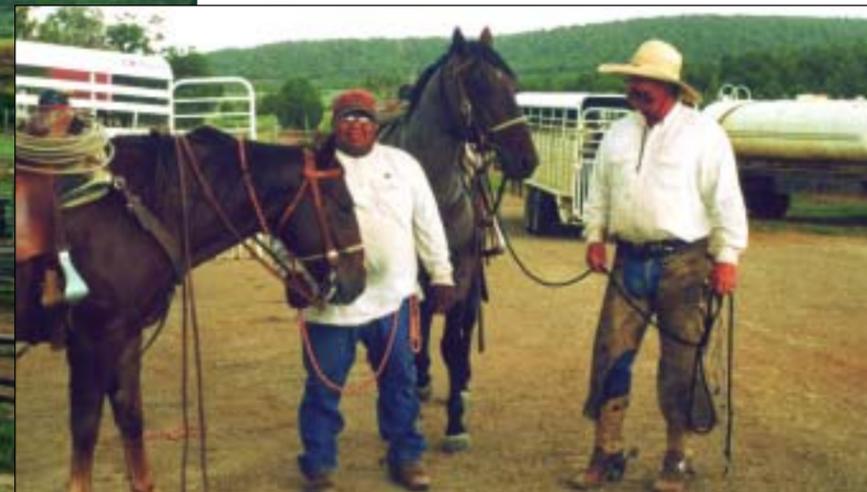
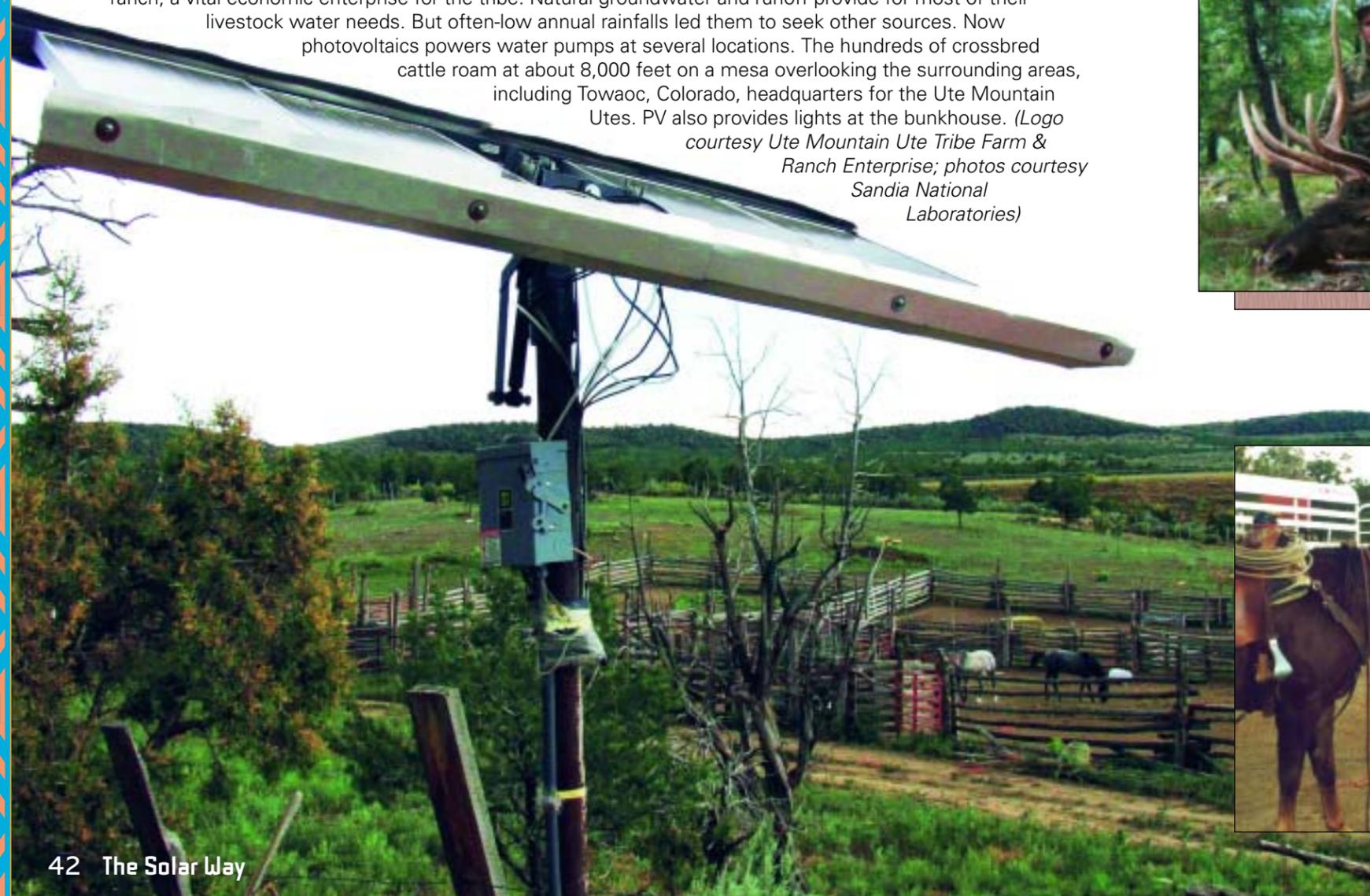
The White Mountain Apache Tribe has been called the anchor of the economy of east central Arizona. They operate successful forest and resort enterprises equal to any, but they also operate one of the most unique economic activities to be found anywhere – their Trophy Elk Hunt, which would not be possible without power brought to them from the sun. Mountain-top PV installations help power the systems not only for routine communications during the hunt, but also for critical law enforcement surveillance and



The Ute Mountain Ute Tribe, located in Colorado (primarily) and New Mexico, rely on their Bow and Arrow cattle ranch, a vital economic enterprise for the tribe. Natural groundwater and runoff provide for most of their livestock water needs. But often-low annual rainfalls led them to seek other sources. Now photovoltaics powers water pumps at several locations. The hundreds of crossbred cattle roam at about 8,000 feet on a mesa overlooking the surrounding areas, including Towaoc, Colorado, headquarters for the Ute Mountain Utes. PV also provides lights at the bunkhouse. *(Logo courtesy Ute Mountain Ute Tribe Farm & Ranch Enterprise; photos courtesy Sandia National Laboratories)*



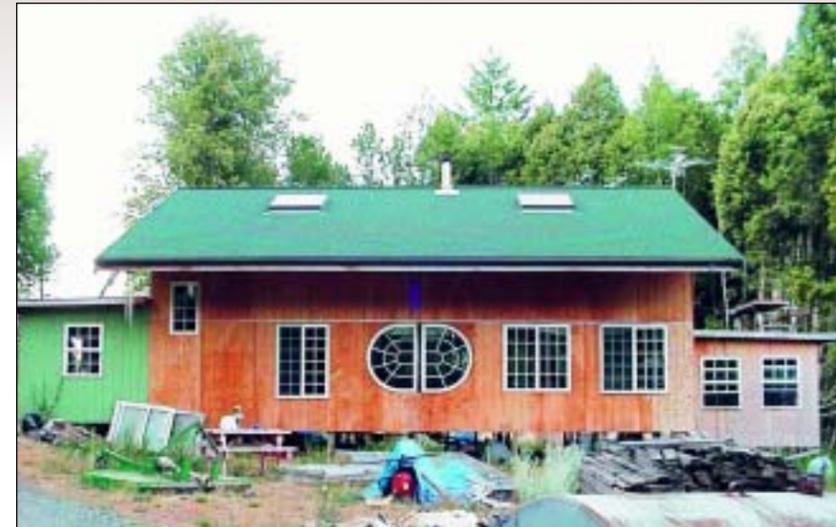
communications. Hunters from all over the world participate, and record-book elk have been taken here. With some permits sold for as much as \$30,000 each, it is easy to see how this business, facilitated by PV, brings more than one million dollars annually to the tribe. *(Photos courtesy Thelma Todachene and Joe Jojola)*



THE POWER OF CHOICE



The Chischilli home on the Navajo Reservation benefits from photovoltaics. A widow, Marie is head of the house and has a comfortable home and a full-time job driving a school bus for the Dilkon School. They had burned up ten generators in previous years, costing them more than twice what their new PV system cost. The PV is mounted atop (and serves to shade) a sandbox. Clearly, photovoltaics was a great choice for this family. *(Photos courtesy Kiss + Cathcart, Architects, and Native American Photovoltaics)*



◀ Arla Ramsey, Vice Chair and Tribal Administrator of the Blue Lake Rancheria in California, chooses to live where no public utilities are available. For her south-facing house she chose a battery system charged by solar and a pelton wheel for a constant trickle charge. With this system, she enjoys all the amenities any homeowner might want. Her security lights are independently solar powered – and help keep the bears away! *(Photo courtesy Arla Ramsey)*

▼ Lewis Jake chooses to live in a traditional Hogan on the Ramah Navajo Chapter lands of New Mexico. He also chooses to continue to use PV for backup power – even though the grid was extended to his home last year. “Power sometimes goes down for two or more days, so I like to use the PV,” Jake says, “because it always works.” *(Photo courtesy Sandia National Laboratories)*





Unlike some reservations, the White Mountain Apaches typically live in electrified communities, but water presents a challenge. One requirement for White Mountain reservation homes is that each be served by a community water supply rather than drilling individual household water wells. Their water storage tanks are on hillsides so as to provide adequate pressure to homes below. These hillside sites are far from the electric grid, and the cost of installing cables from tanks to pumphouses would be prohibitive. After this analysis, the tribe chose photovoltaics to generate electricity for their community water. *(Photos courtesy Indian Health Service, Whiteriver Office of Environmental Health)*



“These photovoltaic projects are a start, but there is much more we need to do. New sources of funding are always welcome, always appreciated. We have a long, long way to go.”

Wilbur Haskie, Zuni Conservation Project, Zuni Pueblo



▲ World-renowned Native American flutist, R. Carlos Nakai, chooses to live off-grid, and chooses to power his home with photovoltaics. The home is located in the southwestern United States, and both home and system were built by the PV supplier. *(Photo courtesy Sundance Solar Designs)*



► The Lower Brule Sioux Tribe in South Dakota needed to put a fence around a wind anemometer on a 175-foot weather tower. Using photovoltaics to electrify just a single strand of wire, they were able to fence the structure in about an hour, where setting posts and running conventional barbed wire would have taken considerably longer – and been much more expensive. Tribal members say the application fits perfectly with their use of other renewable energy sources. *(Photos courtesy Lower Brule Sioux)*



This PV system on the Zuni Reservation waters about 100 head of sheep, brought daily to the tank by the shepherd. When their Aermotor windmill experienced damage due to high winds, the Zunis found it was less expensive to use PV than to repair the windmill. Simply put, the Zuni consider PV their best option. The PV is portable and is rotated from site to site as necessary for watering sheep and cattle. *(Photo courtesy Sandia National Laboratories)*



WHY PHOTOVOLTAICS?

Tribal authorities and individual Native Americans are increasingly recognizing – as are other people throughout the world – that renewable energy systems offer some real advantages when compared with conventional energy: lower operating costs, less vulnerability to fluctuating fuel costs, less harm to the environment, and greater autonomy. Photovoltaics is particularly well suited to providing power for applications far from the electric grid. But when the power of choice is permitted in the equation, then PV is often chosen for the reasons stated above, irrespective of where the PV is located, and irrespective of what the PV powers. In short, the Power of Choice is a powerful multiplier.



Because there was no access to grid electricity, Miriam Hilborn, a member of the Laguna Pueblo (New Mexico) chose PV to generate electricity for her home. This choice means that the Hilborn family can live a fully self-sufficient lifestyle on reservation lands. *(Photo courtesy Sandia National Laboratories)*

ENSURING SYSTEM SUCCESS

Envision the entire project from the outset. Failure to take into account the entirety of your project can create unnecessary expense, unnecessary labor, and an imperfectly designed system.

Early on, spend most of your time understanding what power you need and how the electrical power system you select will meet these needs. Think about where you will put the system: how will it look, sound, or smell; what are its safety and security issues; how will you take care of it?

There are several things to keep in mind – no matter what type of electrical power system you choose. The first of these is to realize that there are choices – engines, solar, extension of electrical lines. Each option has value. Each option has costs. Consider them all as you envision your entire project.

The **Solar Way: Photovoltaics on Indian Lands** presumes that after this thoughtful approach to your power needs, you have chosen the power of the sun.

So how should you begin the process of considering solar electricity? Begin with the knowledge that PV systems are used for almost anything you can think of throughout Indian country, as you've seen within the pages of this book. It's not a question of whether or not a solar electric system can do the job – it can. Now various approaches to the project come into play.

▼ Envision your entire project. Seen here is a residential system in the White Rock/Naschitti area of New Mexico. *(Photo courtesy Navajo Housing Services Department)*



50 The Solar Way

▼ Consider how the system will look. This is a striking example of artistic design elements integrated into a PV installation at the Indian Pueblo Cultural Center, Albuquerque, New Mexico. *(Photo courtesy Sandia National Laboratories)*



You've chosen a system that is quiet. Its only fuel is the power of the sun. And it requires little routine maintenance. Your PV system may cost more than an engine – but it may cost far less than a line extension. You've chosen solar because you have considered not only the initial cost, but its operational costs over the life of the system. You've considered benefits that cannot be accurately calculated, such as the benefit of a soundless system to your quality of life, the benefit of a non-polluting system, and the value of using renewable energy resources.

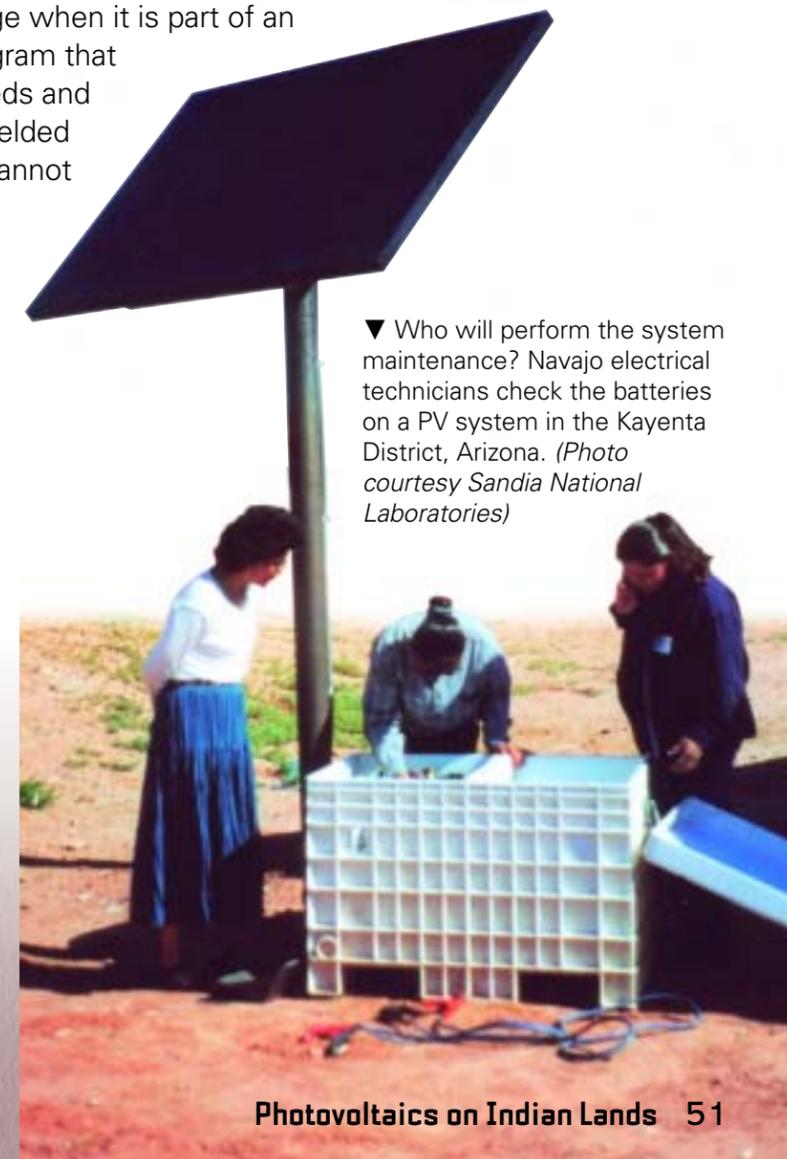
Consider the solar energy supply system together with the pump, or the lights, or any load you will power. For example, a water pump will use on-site generation when no other electrical service is available – so the electrical supply (the PV system) becomes part of the cost of pumping water.

A WORD ABOUT PV AND ENERGY CONSERVATION

Drawing power from the sun for your energy needs makes sense for all the reasons illustrated in this book, but PV is used to its best advantage when it is part of an overall energy conservation program – a program that matches System Design with Customer Needs and one that promotes wise energy use. Many fielded systems are designed so that components cannot be damaged. This means that over-use and overloading cause temporary outages while the PV system regenerates itself without system damage. Proper system operation extends the system's life. **The Solar Way** is intended to help tribes make informed decisions about photovoltaics and help PV customers make informed decisions about how to use their systems to the fullest benefit for the longest period of time. Now



◀ Consider all the benefits that solar electricity can provide. A Sandia National Laboratories staff member explains photovoltaics and what can be expected from a system to a Yurok tribal member. *(Photo courtesy Sandia National Laboratories)*



▼ Who will perform the system maintenance? Navajo electrical technicians check the batteries on a PV system in the Kayenta District, Arizona. *(Photo courtesy Sandia National Laboratories)*

you're ready to see if there are local businesses that can help you buy a system and get it properly installed. Affordability may be an issue at this time. Really simple system packages such as for area lighting or electric fencing are almost off-the-shelf, have set prices, and are easy to install. Other projects will require custom design and assembly. It is these systems that benefit most from the expertise that the local PV industry, electricians, engineers and architects, and energy consultants can provide.

If your tribe will be responsible for operating the PV system, consider all the operational costs that will be involved, and consider the investment in training staff, and the value of training customers or those who will actually be using the system. How will your systems be maintained? For larger systems, it may be advisable to purchase an extended warranty from a qualified business. For smaller systems, a warranty may also be desired, and it would be our recommendation that for ease of operation and maintenance, this 'after-sales assistance' be purchased from your system supplier. Other considerations such as cleaning or weeding can be performed by nearly anyone.

What about financial considerations? A project involving solar electric power should not necessarily be presented to potential lenders any differently than one incorporating a conventional power system. Take advantage of solar 'set-aside funding' where it exists, and consider any innovative approaches to environmental or resource management your project allows when selling the idea to a funding agency or lender.

What about technical assistance? Sandia National Laboratories and its partners can help, as can the overall PV industry and the system integrators, installers and consultants. But to ensure sustainable projects – those that will survive best the test of time – your tribe should develop its own internal expertise, its own infrastructure, and its own commitment to solar electricity.

We have presented solar as an enabling technology. But the technology is only part of the story. The rest of the story is the user and how the system is used.

Using photovoltaics means looking at things in a new way, which is really a very old way. Solar and geothermal greenhouses provide opportunities for economic development through increased output from the land and reduction of water consumption. Solar electric systems on homes and businesses complement the use of natural lighting to reduce the use of expendable resources and pollution. The wind – another solar resource – can be used with PV systems to provide more consistent power output.

These concepts need to be stressed in our educational efforts. They fit easily with even conventional classroom and laboratory programs for children and adults. Community support is important. All the education in the world means little until it is applied. As solar projects increase, support businesses can develop, and more high tech sales and service job opportunities can become available. Ultimately, it is these people who will champion the solar way and become the key to sustainable solar development.



A sustainable project on the Cuyapaipe Reservation, California. Shown are the system as it was installed by the Indian Health Service in 1978, and today (top photo), still powering a village water system. (Photos courtesy Cuyapaipe Tribe and Sandia National Laboratories)



Advocates - and future PV advocates!



Photos courtesy Hopi Foundation (upper right); Center for Permaculture as Native Science (bottom); Sandia National Labs (upper left).

THE POWER OF THE SUN



More than 200 Native, Eskimo, and Aleut villages throughout Alaska.

Indian Lands ■ PV System Sites ◆

Photovoltaics can serve your energy needs wherever the sun shines – whether in a locale with a very high solar value or in a locale with less solar radiation. This map shows Indian lands throughout the United States. The PV symbols represent PV systems or families of systems (sometimes fewer than a dozen; sometimes hundreds) known to be in use on those lands.

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